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ANALYSIS OF DISTANCE PROTECTION RELAY IN PRESENCE OF STATIC SYNCHRONOUS COMPENSATOR (STATCOM)

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ABSTRACT

Distance relay is most popular in protection of High Voltage and extra high voltage transmission lines science many decades. In this paper analysis of distance protection relay employing with STATCOM on transmission line is done by using the simulation. Also effect of static synchronous compensator (STATCOM) on the distance protection relay under normal and abnormal conditions is investigated. However traditional updating of transmission lines is difficult. To fulfill power demand on the system need to utilize existing power system with the help of flexible alternating current transmission system (FACTS), but this will affect the traditional protection scheme for transmission lines. Simulation result clearly shows the impact of STATCOM on distance protection scheme during fault conditions. A typical 400KV, 300KM long transmission line with 100MVA STATCOM in MATLAB/Simulink is studied.

Keywords: Distance Relay, Power System Prtoction, STATCOM, Modeling, Faults, MATLAB/ Simulink.

I. INTRODUCTION

Modern power system are designed to operate effectively to supply power from utility to distribution centers with very high reliability and optimum cost. Demand for electrical energy continuously growing steadily, especially in developing countries like India where growth of industrialization rapidly increasing. To fulfill these new power demand on power system, need to develop new infrastructure but constructing new transmission lines is very difficult due to economic and environmental limitations.

Finding suitable right ways is particularly difficult in the developing countries and gaining the necessary approvals is more time consuming than ever. Due to these situations, operators are looking for ways to utilize these existing power lines more effectively. Flexible alternating current transmission system (FACTS) have all these capability to meet the challenges presented by the fast growing power system. The term FACTS covers all modern power electronics based system used in ac power transmission system.

Following are the benefits of using FACTS devices in transmission line.

i) Steady state transmittable power can be improved.
ii) Voltage profile can be improved.
iii) Better utilization of existing transmission lines.
iv) System Power factor has been improved.

However, the employing of FACTS devices like static synchronous compensator (STATCOM) in transmission lines have a profound impact on the operation of other equipment in the system especially the protection relay [1].

Particularly the transients superimposed on power frequency voltage and current waveforms will be affected in both steady state and transient state, particularly during fault conditions can be significantly different from those of system without STATCOM in which many system parameters are different like line impedance and power angle. And this will affect the conventional protection system based on Impedance relay [2].

Literature review indicate that FACTS device introduce new power system dynamics that must analyzed. These are summarized as:

i) The rapid changes in system parameters such as line impedance, power angle and line currents.
ii) The harmonics establish into the adjacent ac power system.
iii)Transients introduced into the system due to center action.

Thus it's very important to study the effects of FACTS devices such as STATCOM on protection relay scheme for transmission line [1] - [3].

STATCOM is belonging to FACTS family and most popular in midpoint compensation technique.

It depends on voltage source converter (VSC) techniques and can inject an almost sinusoidal current with variable magnitude and almost in quadrature with the connecting line voltage of the bus [4]-[5].

Mid –Point compensation technique is widely used, in mid –point compensation technique transmission line get separated into two equal parts with equal impedance division of transmission line. first segment can deliver power from sending end to mid –point with equivalent impedance of line is Z/2 and second segment from mid-point to receiving end with an equal impedance of Z/2 respectively [4].

The study in [2] and [7] show that the presence of FACTS device and its location had great impact on impedance relay. Particularly when FACTS device is in fault loop, its voltage and current injection will affect both steady and transient components in voltage and current and hence the apparent impedance seen by a conventional distance relay is different from that of a system without FACTS device.

In this paper, analysis of distance relay in presence of STATCOM on transmission line and investigate the impact of STATCOM on distance relay in normal and abnormal condition are studied. Detail model of transmission line having 400KV, 300Km with distance relay and STATCOM is proposed.

II. DISTANCE RELAY

One of the most important equipment employed in the protection of power system are protection relay. These are one of the most flexible, economic and well known device that provide

reliable, fast and inexpensive protection. Distance relay have been using successfully from many years and most popular type of protection for transmission lines. Distance relay operation based on the measurement of impedance at the relay point to fault point and compare it with predefine set value. In conventional protection scheme measure impedance by a distance relay depends only on the length of the line section located between the fault and the relaying located point. But in case of FACTS employing transmission line protection scheme impedance depend on FACTS operation during fault condition [6].

Consider the proposed distance protection scheme shown in fig.1. The apparent impedance calculation is based on symmetrical components transformation technique using power frequency components of voltage and current signal measured at relay point.

A transmission line with three zones protection scheme is considered. In which reach setting of zone one is up to 80% of the protected line impedance for instantaneous zone one protection. For zone second it should be 120% and for zone third it should be 140-150% of the protected line impedance. Fig.2 shows typical three zone Mho type distance protection scheme.

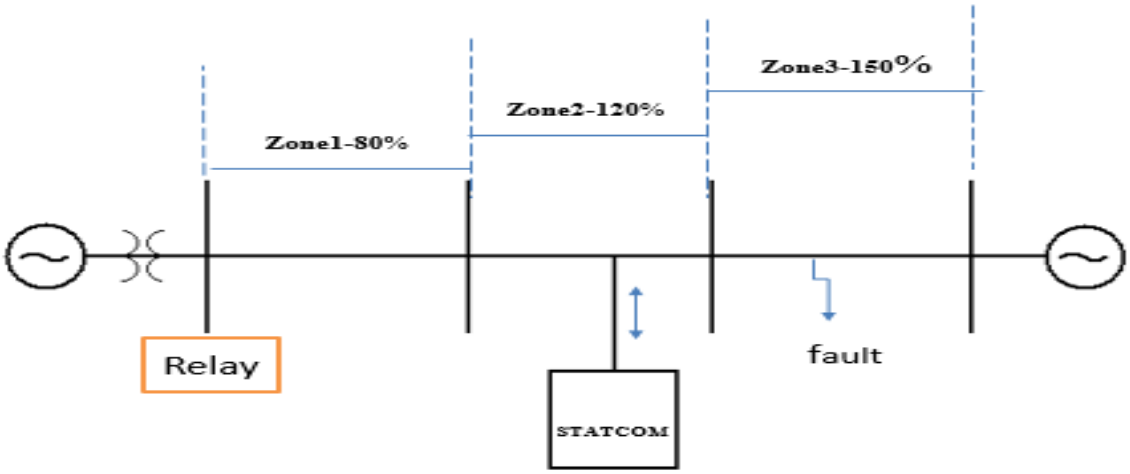

Fig. 1. Proposed distance protection scheme with STATCOM at midpoint compensation.

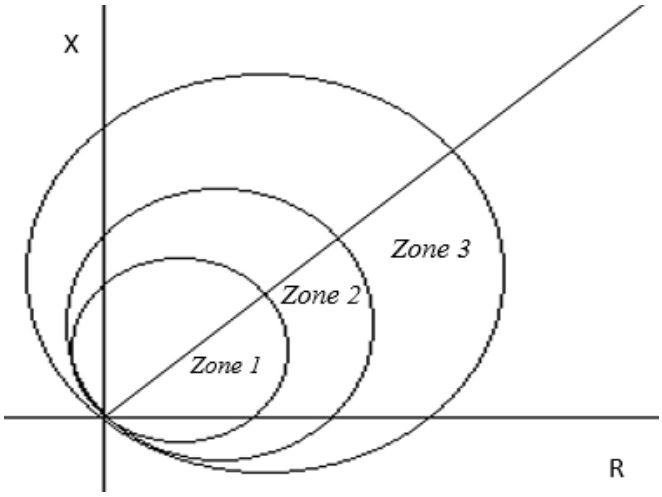

Fig.2 Typical three zone distance protection scheme

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III. SIMULATION SCHEME

A) Simulation scheme for distance Protection relay

Distance relay can be design using simpower system design tool in Matlab Simulink which is shown in fig. 3. Following steps are required for distance relay modeling in simulation work space.

1. Input signal: current and voltage waveforms are captured from the instrument transformers and scale down to desire level for further processes.
2. Filtering Block: By using low pass filter remove the noise and undesired components of frequencies from the input signals.
3. Quantizer: This block convert input sinusoidal signal into stair step form, so that many closed points on the input signal are mapped on one point on the output axis. It represent as y = q*round (u/q). Where q is quantization interval and u is input.
4. Digital Filtering: second order finite impulse responses type digital filter block preferred for distance relay modeling. Main role of this block is to convert analog signal to discrete signal.
5. Discrete Fourier: DFT is ideal method of detecting the fundamental frequency components in fault signal. It compute the magnitude and phase at discrete frequencies at discrete time intervals.
6. Algorithm: Algorithm part required for decision of trip command for final output.

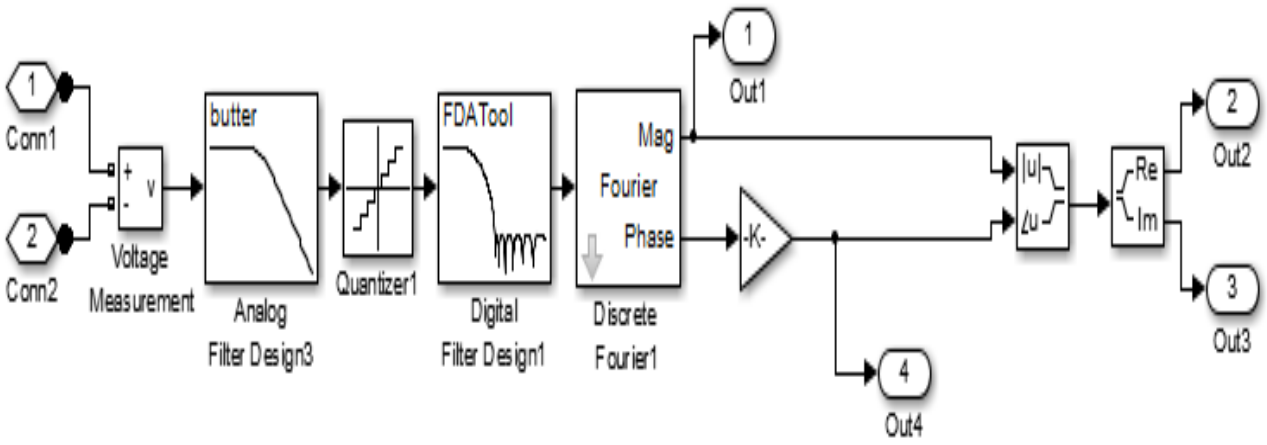


Fig.3. Block diagram of distance relay model

B) Simulation scheme for STATCOM:

Fig.4 show the STATCOM and its controller. Voltage source converter, PWM generator and PI controller, are the main parts of STATCOM.

1. Voltage source converter (VSC): Main part of the STATCOM is voltage source converter in which bridge of IGBTs are used for converter. In VSC at dc side dc capacitor banks utilize as a dc energy source.
2. PWM generator: PWM generator used for generation of gate pulse for IGBTs Bridge. In this technique sinusoidal sine wave is compared with carrier triangular wave. By varying the modulation index, converter output is vary.
3. PI controller: Error signal from input and VSC output given to the PI controller which can control the modulation index.

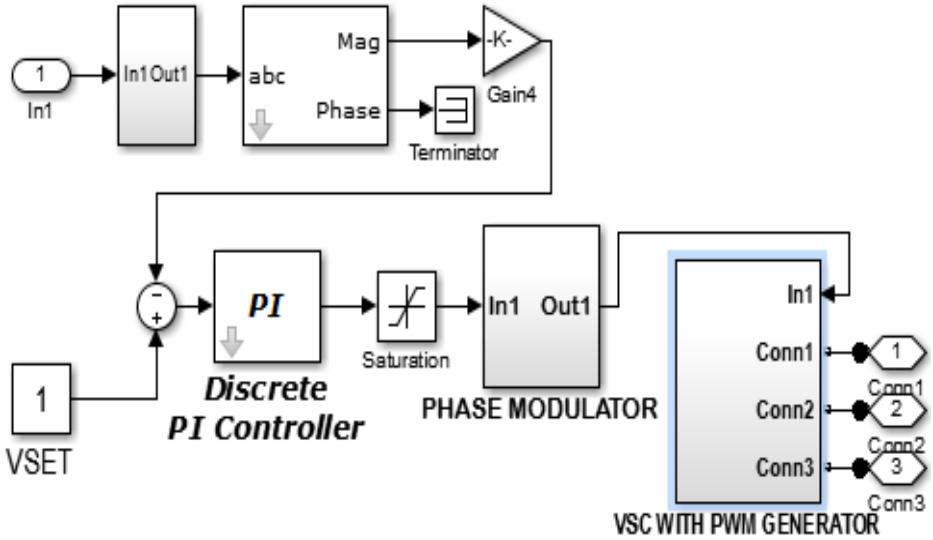


Fig.4. STATCOM with its controller.

IV. SIMULATION RESULT

To demonstrate the impact of STATCOM on the distance protection relay Matlab Simulink model of 400KV, 300KM transmission model with 100MVA STATCOM and distance relay has been developed. A single phase to ground fault is considered in zone 1, zone 2 and zone 3 respectively. Also simulation result in the form of apparent impedance trajectory by the distance relay are shown in fig. 6(a -b) -fig.8 (a-b) and fig. 5 shows proposed simulation scheme.

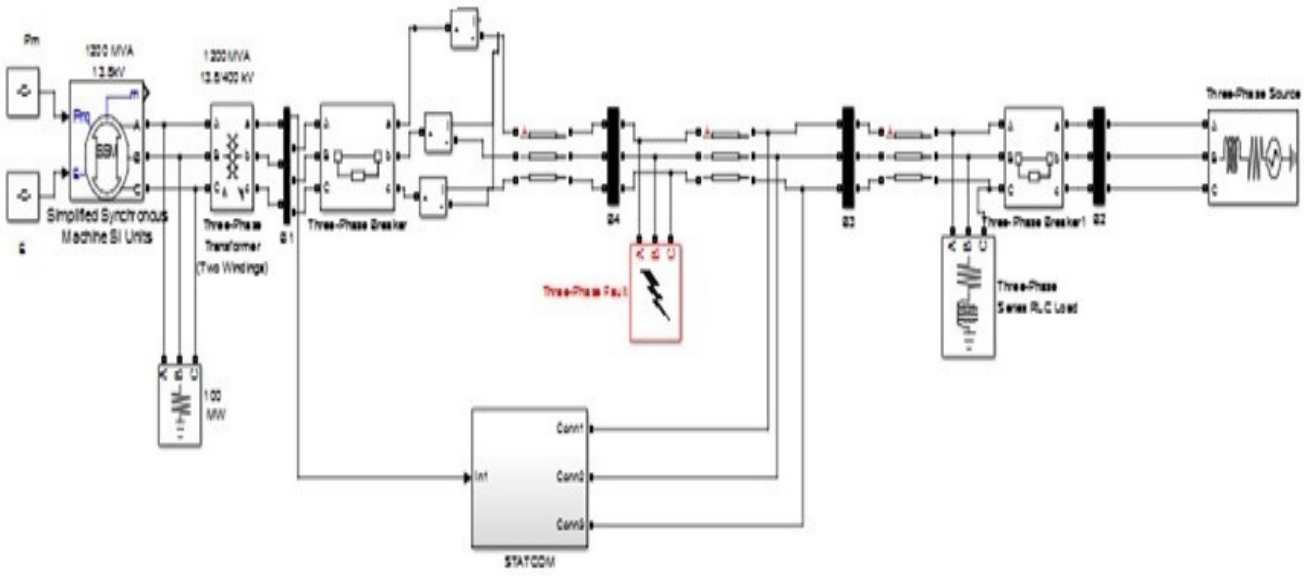
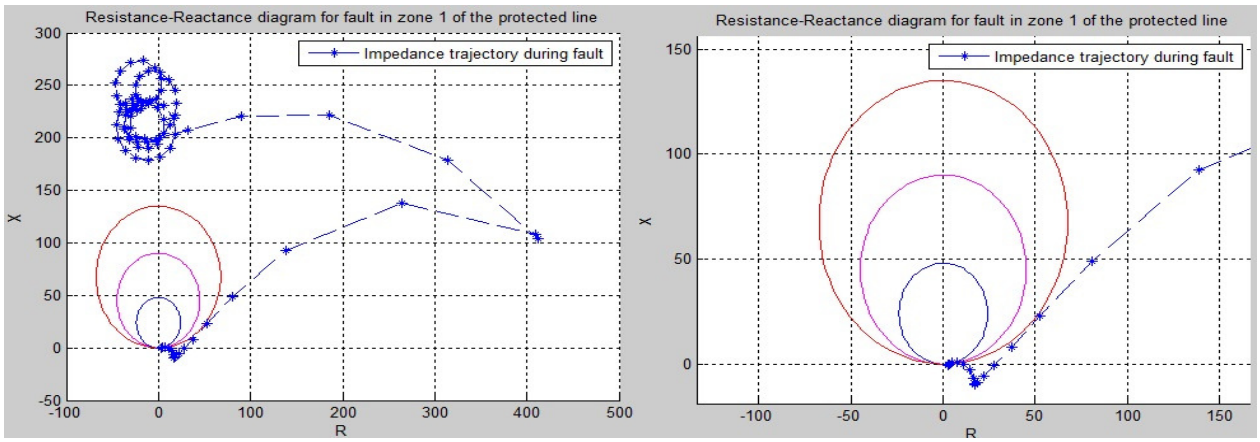
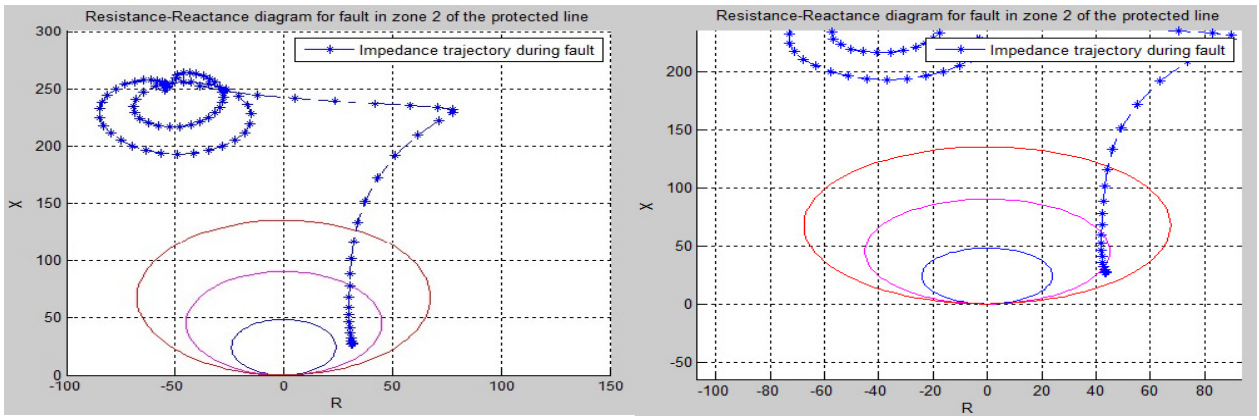


Fig.5. Proposed simulation scheme



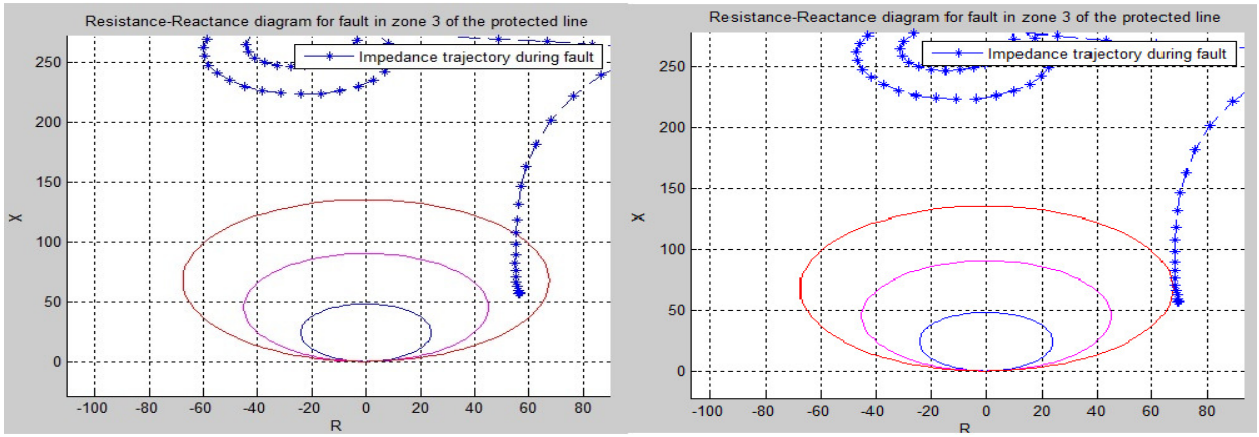
A. Without STATCOM B. With STATCOM

Fig.6. Apparent impedance seen by relay during SLG fault in zone 1.



A. Without STATCOM B. With STATCOM

Fig.7. Apparent impedance seen by relay during SLG fault in zone 2.



A. Without STATCOM B. With STATCOM

Fig. 8. Apparent impedance seen by relay during SLG fault in zone 3.

V. CONCLUSION

In this paper, the impact of STATCOM on a transmission line distance protection relay under the single phase to ground fault condition is investigated by MATLAB/Simulink.

Fig.6– fig.8 shows the impedance trajectory of distance relay during fault, with and without STATCOM conditions. It clearly show the overreaching phenomenon on distance relay due to STATCOM installed on line. Its voltage and current injection will affect both steady and transient components in voltage and current and hence the apparent impedance seen by a conventional distance relay is different from that of a system without STATCOM device, which affect the traditional protection scheme of a transmission line.

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